**Course Syllabus, Learning Objectives, Principles and Exercises**

**Water cycle**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Week** | **Topic/Lesson** | **Learning Objectives** | **Causal Principles** | **Inclass exercise** |
| 1 | Intro |  |  |  |
| 1 | Lesson 1.  Water Cycle:  Introduction | 1A. Describe the molecular nature of water |  | Noah’s intro exercise |
| 2 | Lesson 2.  Water Cycle: Reservoirs and Residence Time | 2A. Describe the reservoirs of water and the residence time of water in these reservoirs |  |  |
| 2 | Lesson 3.  Water Cycle: Residence Time & Causal Processes | 3A. Define the processes that move and change water |  |  |
| 2 | Lesson 4.  Water Cycle: Causal Processes & Principles | 4A. Use box and arrow diagrams to describe movement and change of water from one reservoir to another.  4B. Define and give examples of kinetic and potential energy | 1, 4, 5, 8, 9 | Reservoirs exercise |
| 3 | Lesson 5.  Water Cycle: Potential & Kinetic Energy | 5A. Define and provide examples of equilibrium. | 2,3 | Energy exercise |
| 3 | Lesson 6.  Water Cycle: Summary of Principles | 6A. Summarize the principles that explain the process that cause movement and change in the hydrosphere | 1-9 |  |
| 3 | Lesson 7.  Water Cycle: Solar Energy & Atmospheric and Oceanic Circulation | 7A. Describe how solar energy drives movement and change in the hydrosphere | 1, 6, 7 |  |
| 4 | Lesson 8.  Water Cycle: Groundwater | 8A. Describe how groundwater moves and changes | 5 | Circulation exercise |
| 4 | Lesson 9.  Water Cycle: Evidence for Past Changes | 9A. Describe evidence for past, large-scale changes in the water cycle. |  |  |
| 4 | Lesson 10.  Water Cycle: Future Changes | 10A. You will be able to state some predicted consequences for the water cycle of continued global warming. | 6,7,8,9 |  |
| 5 | Lesson 11.  Water Cycle: Ethics | 11A. You will be able to place an ethical decision into one or more of the five categories. |  | I suggest both classes do an activity on ethics.  I could develop an analogy exercise- are the ethical consideration about climate change the same as those about XXX. |
| 5 | Lesson 12.  Water Cycle: Responding to Freshwater Crisis | 12A. You will be able to propose a reasonable response to water shortages in the southwestern region of the United States. |  |  |
| 6 | Lesson 13.  Water Cycle: Review |  |  | test |

**Plate Tectonics**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 7 | Lesson 14.  Plate Tectonics | 1. Describe plate tectonic theory and the kinds of evidence that supports the theory |  |  |
| 7 | Lesson 15.  Plate Tectonic Boundaries | 1. Describe the interior of the earth- inner core, outer core, mantle, crust, asthenosphere and lithosphere 2. Draw the plate boundaries |  |  |
| 7 | Lesson 16.  Buoyancy and Convection | 1. Explain buoyancy and how it causes tectonic plates to move 2. Describe the role of thermal and gravitational energy in convection. | 1,5, 7 | Convection exercise |
| 8 | Lesson 17.  Processes at Plate Boundaries | 1. Explain why most earthquakes occur at plate tectonic boundaries 2. Explain why most magmas, and therefore, volcanoes form at plate boundaries. | 4,5, 7 |  |
| 8 | Lesson 18.  Rock Cycle, part I | 1. Define igneous, sedimentary and metamorphic rocks 2. Describe the roles of temperature, pressure and water in melting | 3,4 |  |
| 8 | Lesson 19  Rock Cycle, Part II | 1. Explain how buoyancy causes uplift. | 7 | Buoyancy exercise  Or metamorphism exercise? |
| 9 | Lesson 20.  Calcium Cycle, Part I | 1. List the major calcium reservoirs 2. Calculate the residence time of Ca in the oceans and in limestones 3. Describe the movement and change of Ca from calcium silicate to calcium carbonate and back again to calcium silicate with reference to the following equation.   CO2 + H2O + Ca-silicate ↔ CaCO3 + silica + clay  Note: you do not need to memorize this equation but you do need to be able to describe what it represents. | 3,4 |  |
| 9 | Lesson 21.  Calcium Cycle, Part II | 1. Describe calcium dissolution and precipitation of calcium carbonate. 2. List 2 similarities and 2 differences between the calcium cycle and the water cycle. | 3,4 | Chemical energy exercise |
| 9 | Lesson 22.  Carbon and the rock cycle | 1. Describe how oil, gas and coal form. 2. Use a box and arrow diagram to trace organic carbon from the biosphere through the lithosphere. | 1 thru 9 |  |
| 10 | Lesson 23.  Review |  |  | test |

**Carbon Cycle**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 11 | Lesson 24.  Introduction to Global Climate Change | 1. Describe the earth’s energy balance. 2. Explain why the term “greenhouse” is not a perfect analogy for how CO2 helps keep our planet warm. | 6 | Greenhouse analogy exercise |
| 11 | Lesson 25.  Carbon: Matter and Reservoirs, Part I | 1. Describe the common carbon containing molecules in each reservoir. 2. Describe the process that move and change carbon from one reservoir to another. | 1,2,3,4,8,9 |  |
| 11 | Lesson 26.  Carbon: Matter and Reservoirs, Part II | 1. Use information on fluxes and reservoir sizes to calculate residence times of carbon in various reservoirs |  |  |
| 12 | Lesson 27.  Principles that move and change matter | 1. Give an example of how 6 of the of the 10 principles can be used to predict climate change. 2. Give examples of positive and negative feedback in the climate system. | Principles 1-10 | Positve and negative feedback exercise |
| 12 | Lesson 28.  Evidence of Past Climate Change | 1. Define abrupt climate change and explain some of the evidence that it has occurred in the past. 2. Explain why scientists think positive feedback plays a role in abrupt climate change. 3. Describe evidence scientists use to infer paloeclimates. | 4, 10 |  |
| 13 | Lesson 29.  Predicting the Future | 1. State how changes in global climate are expected to affect U.S 2. Draw a graph comparing change with feedback to linear change without feedback. 3. Explain how climate models are constructed and why this leads to uncertainty in predictions. | 10 | Prediction from principles exercise- this will be about predictions of stock market trends versus CO2 trends. |
| 13 | Lesson 30.  Climate Change Ethics | 1. Describe how the discount model for determining the value of future goods is similar to the model we used to predict costs of the increase in global carbon emissions. |  |  |
| 13 | Lesson 31.  Are there alternatives to the climate disaster? | 1. Identify 3 main approaches we might use to address global climate change. 2. Describe problems and/or reasons to doubt each approach | 1,6,9 |  |
| 14 | Lesson 32.  Review |  |  | Geoengineering (with SO2) vs eruption exercise |
| 15 | Lesson 33.  Course Review |  |  |  |